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(54) Method for joining FRP material with vulcanized rubber.

(57) An exothermic material, e.g., a dielectric, ferromagnetic or conductive material is blended in an adhesive (1), in a particulate form (3) or laminated therewith as a foil or tape (6). The adhesive including exothermic material is positioned between surfaces of FRP material (2) and vulcanized rubber (4). High frequency or electrical heating is applied until exothermic reaction sufficient to raise the temperature of the adhesive for joining the FRP material and the vulcanized rubber is obtained.

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## METHOD F R J JOINING FRP MATERIAL WITH VULCANIZED RUBBER

### BACKGROUND OF THE INVENTION

#### Field of The Invention

The present invention relates generally to a method for joining FRP material with vulcanized rubber. Specifically, the present invention relates to a method for joining FRP material with vulcanized rubber using an adhesive agent.

#### Description of The Background Art

Generally, methods for joining metallic material with vulcanized rubber have been well known in the skilled art. For example, Japanese Patent Second Publication (allowed) No. 59-19018 discloses such a method. An adhesive is applied to a surface of a metallic material, then the surface is pressed to seal with a surface of vulcanized rubber. Thereafter, the sealed surfaces are heated at 150°C to 250°C for 0.5 to 3.0 min. The adhesive is thus melted by exothermic reaction with the metallic material and sealing is accomplished.

On the other hand, recently, mechanical strength of FRP (Fiber Reinforced Plastics such as Graphite FRP or Carbon FRP) materials have been greatly advanced. Structural bodies formed of FRP have been utilized in certain applications instead of metallic materials.

However, there are certain problems in the case of joining FRP materials with vulcanized rubber.

First, adhesion techniques used for metallic materials cannot be applied for FRP materials. Principally because when FRP is entirely heated, mechanical functions thereof, particularly mechanical strength and geometrical accuracy, are extremely degraded. Therefore, utility of heated FRP cannot be expected. Adhesives of a non-heated type (adhered at ambient temperature) are also available, however, when surrounding temperatures rise to more than 100 °C, the adhesion strength of these adhesives are deteriorated extremely. Therefore, because of lack of adhesion reliability, this method also cannot be applied, especially for joining of mechanical structures.

Secondly, adhesion techniques for FRP materials with vulcanized rubber have not been established substantially. Therefore, in spite of FRP materials being substantially available as a replacement for metallic materials, as far as mechanical strength is concerned. Effective replacement is hindered because of the lack of adhesion reliability thereof.

### SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to provide a method for joining FRP material with vulcanized rubber using an adhesive material.

It is another object of the present invention to provide a method for joining FRP material with vulcanized rubber without degrading the mechanical properties of the FRP material.

It is a further object of the present invention to provide a method for joining FRP material with vulcanized rubber with high adhesive strength and reliability.

It is furthermore an object of the present invention to provide an adhesive material having high adhesive strength and reliability, so as to join FRP material with vulcanized rubber.

According to one aspect of the present invention, a method for joining FRP material and vulcanized rubber is composed of blending exothermic material into an adhesive material, applying said adhesive material between facing surfaces of FRP material and vulcanized rubber to form a lamination, pressing said lamination, and heating said lamination substantially enough to induce exothermic reaction of said exothermic material for establishment of adhesion between said FRP material and said vulcanized rubber.

The exothermic material may be a dielectric material selected from the groups consisting of barium titanate, and highmolecular compounds comprising polyacrylonitrile, and polyvinyl chloride.

Replacement of the exothermic material by ferromagnetic material selected from the group consisting of iron, nickel, cobalt and ferrite is also preferable.

Alternatively, the exothermic material may also be conductive material selected from the group consisting of carbon black, aluminium, copper, chromium, nickel, stainless steel and zinc.

The dielectric material is exothermically reacted by dielectric heating, the ferromagnetic material is exothermically reacted by induction heating, the conductive material is exothermically reacted by electric heating.

### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiments of the invention. However, the drawings are not intended to imply limitation of the invention to a specific embodiment, but are for explanation and understanding only.

In the drawing :

Fig. 1 is a sectional view of a first or second embodiment according to the present invention :  
 Fig. 2 is a sectional view of a third embodiment according to the present invention ;  
 Fig. 3 is a sectional view of a fourth embodiment according to the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, particularly to Fig. 1 indicating a first embodiment of the present invention, an adhesive material 1 is applied on a surface of FRP material 2 formed of epoxy resin, such as GFRP or CFRP, or aramid FRP (using aramid fiber reinforcement). As the adhesive material 1, halogenated rubber, phenol and/or isocyanate type adhesives are preferable. Particles of ferromagnetic materials 3 such as particles of iron, nickel, cobalt, or ferrite are blended in the adhesive material 1 beforehand at a desired blending ratio. Then vulcanized rubber 4 is layered on the surface of the FRP material 2 where the adhesive 1 is applied, and pressed thereagainst. The rubber material 4 may be formed of at least one of natural rubber, and synthesized rubbers such as SPR, BR, EPDM, CR. High frequency heating is applied by a coil 5 of a high frequency heating equipment (not shown in drawing) activated at a frequency less than 40 MHz. Exothermic reaction is derived from within the adhesive 1 including the particles of ferromagnetic materials 3 by induction heating, and the temperature of the adhesive 1 rises immediately to adherable temperature, thus joining of the FRP material 2 with the vulcanized rubber 4 can be accomplished.

While high frequency heating is applied, the heated area is limited to the area where sufficient induction heating can be derived. That is, no more than a small area adjacent the joining surfaces of both the FRP material 2 and the vulcanized rubber 4 are heated. Therefore, both materials are never heated entirely and deterioration thereof does not occur.

According to a second embodiment of the present invention, instead of ferromagnetic materials 3, particles of dielectric materials selected from such as barium titanate, polyacrylonitrile, polyvinyl chloride may alternatively be blended in the adhesive material 1 to obtain same effect. In the case, the adhesive material is exothermically reacted from within by dielectric heating derived from the high frequency heating. Heating conditions determined at more than 10 MHz are desirable according to this method.

Alternatively, in a third embodiment of the present invention, ferromagnetic materials configured in foil or tape may be used together with the adhesive. In this case, a foil or tape of ferromagnetic material 6 is applied on the surface of the FRP material 2 via the adhesive 1 to form a lamination as shown in Fig. 2.

The vulcanized rubber 4 is pressed against the ferromagnetic foil or tape 6 via the adhesive 1. High frequency heating is applied to the lamination thereafter. In addition, forming numerous holes in the foil 6 beforehand is a preferable method of ensuring adhesive strength.

Referring now to Fig. 3 indicating a fourth embodiment according to the present invention, using an adhesive together with conductive materials is also possible. A conductive coating material 7 is applied on the surface of the FRP material 2, the adhesive 1 is laminated thereon, then vulcanized rubber 4 is pressed on the adhesive 1. The conductive coating 7 is exothermically reacted electrically by the electrical source 9 via electrodes 8, 8 disposed on both edges of the coating 7. As the heated area of the FRP material 2 and the vulcanized rubber 4 are limited to an area within the joining surfaces thereof, the mechanical strength of each material cannot be deteriorated, unlike conventional adhesion techniques.

Additionally, conductive materials such as aluminum, chromium, nickel or stainless steel configured in foil or tape may be used instead of the conductive coating 7 in the same manner shown in Fig. 2. Alternatively, particles of carbon black, aluminum, copper, are also preferable as conductive materials. It is also possible to deposit aluminum, zinc or such, directly to the joining surface by such as flame spraying.

Thus, materials included in the adhesive are exothermically reacted by dielectric heating, in the case of using dielectric material, by induction heating. In case of using ferromagnetic material, by electric heating in case of using conductive material. In all cases, the adhesive is heated rapidly to an adherable temperature, then the FRP material and the vulcanized rubber can be joined strongly via the adhesive. These materials act as exothermic bodies, and no more than the joining area of the FRP and the rubber are heated. Therefore, the whole body of the FRP and the rubber are never heated and the temperature may be raised rapidly without deteriorating the mechanical or geometric characteristics of either material. Additionally, adhesive strength and reliability can be greatly advanced.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding of the invention, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the inventions as set forth in the appended claims.

**Claims**

1. A method of bonding a fiber reinforced plastic (hereinafter FRP) material and a vulcanized rubber comprising positioning an adhesive and a heat-generating material between opposed surfaces of FRP material and vulcanized rubber to form a laminate, applying pressure to the laminate, and raising the temperature of the heat-generating material sufficiently to establish adhesion between the FRP material and the vulcanized rubber.

2. A method as claimed in claim 1, wherein the fiber reinforcement of the FRP material is glass fiber, carbon fiber, aromatic polyamide fiber, or a mixture of two or more such fibers.

3. A method as claimed in claim 1 or claim 2, wherein the vulcanized rubber is natural rubber, or a synthetic rubber, for example, SPR, BR, EPDM, and CR, or a blend of two or more such rubbers.

4. A method as claimed in any one of claims 1 to 3, wherein the heat-generating material is one that generates heat on being subjected to electrical, electromagnetic, or magnetic forces.

5. A method as claimed in any one of claims 1 to 4, wherein the heat-generating material is a dielectric, for example barium titanate or a high molecular material having a high loss factor e.g., polyacrylonitrile or poly(vinyl chloride), the heating advantageously being effected by dielectric heating, preferably by high frequency heating at up to 10 MHz.

6. A method as claimed in any one of claims 1 to 4, wherein the heat-generating material is a ferromagnetic material, for example, iron, nickel, cobalt or ferrite, the heating advantageously being effected by induction heating, preferably by high frequency heating at at least 10 MHz.

7. A method as claimed in any one of claims 1 to 4, wherein the heat-generating material is an electrically conductive material, for example, carbon black, aluminum, copper, chromium, nickel, stainless steel, or zinc, and the heating is effected by electric heating.

8. A method as claimed in any one of claims 1 to 7, wherein the adhesive material is a halogenated rubber, a phenolic adhesive or an isocyanate adhesive.

9. A method as claimed in any one of claims 1 to 8, wherein the heat-generating material is dispersed throughout the adhesive, advantageously in particulate form.

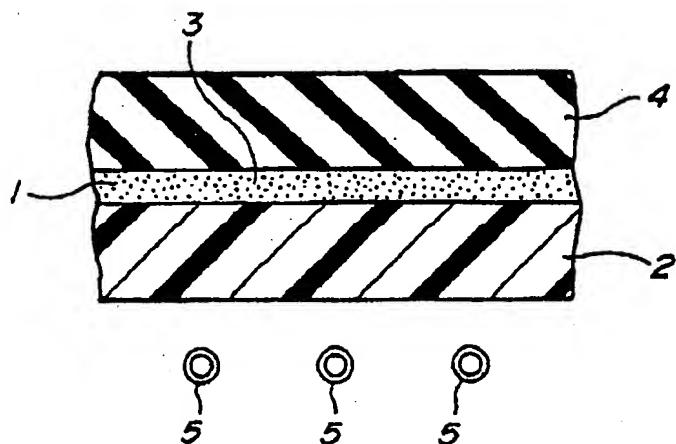
10. A method as claimed in any one of claims 1 to 8, wherein the heat-generating material is applied in the form of a tape or film, advantageously having apertures therein to allow formation on heating of a continuous mass or layer of adhesive between the FRP and vulcanized rubber surfaces, or being miscible with the adhesive on heating to form a continuous adhesive layer.

11. A method as claimed in claim 7, or in claim 8 as dependent on claim 7, wherein the conductive material is deposited directly on the surface of the FRP material, advantageously by flame spraying.

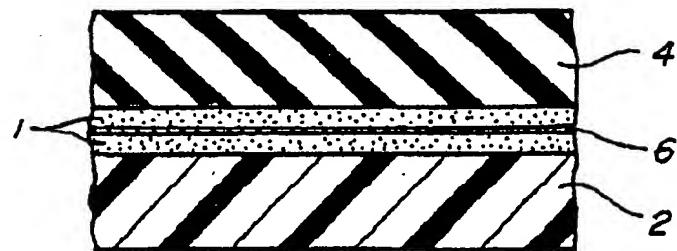
12. The use of a heat-generating material, especially one activatable by electrical, electromagnetic, or magnetic forces, to raise the temperature of a heat-activated adhesive with which it is in thermal contact to a temperature sufficient to activate the adhesive to bond surfaces which are of a material or materials that is or are sensitive to heat, for example, fiber reinforced plastics and elastomers.

13. An adhesive material for joining FRP material and vulcanized rubber comprising exothermic material in a proportion sufficient to cause exothermic reaction to reach an adhesion temperature for said adhesive material.

**FIG.1**



**FIG.2**



**FIG. 3**

